PRELIMINARY PROPOSAL,

REMOTE SENSING AND RELATED SEISMOTECTONIC ANALYSES

FOR

FAULTS AND FOLDS OF THE

YAKIMA FOLD BELT,

WASHINGTON

by

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REMOTE SENSING ANALYSIS OF FAULTS AND FOLDS OF THE YAKIMA FOLD BELT, WASHINGTON

NEED FOR ANALYSIS:

Several factors make this type of study important to understanding the seismotectonic setting of the Hanford area:

First, a maximum earthquake of magnitude 6.5 has been proposed for the RAW (Rattlesnake-Wallula Alignment), CLEW (Cle Elum-Wallula Lineament, or OWL (Olympic-Wallula Lineament). This magnitude is based on a length of about 120 km along a zone that may be longer if the orginal definition for OWL is assumed, or if westward extensions concealed by the Yakima Fold Belt, or if there is a change in orientation of the zone toward La Grande graben. The fault zone, marked at the surface by discontinuous faults, brachydomes and anticlines, is inferred to be a right-lateral or right-reverse oblique type (Slemmons, 1982a and 1982b). The right-lateral or right-reverse oblique character is inferred from the non-definitive literature for this zone. The maximum earthquake for the Yakima Fold Belt, which adjoins the BWIP site, was estimated by Slemmons (1982a; 1982b) to be of 7.2 to 7.6 magnitude at Toppenish Ridge.

Second, studies of recent earthquakes by Berberian (1982) for Tobas-E-Golshan in Iran (Ms = 7.5), by Philip and Meghraoui (1983) and Meghraoui and others (1986) for El Asnam area in Algeria (Ms = 7.25), and by King and Stein (1983 and 1984) for Coalinga area in California (Ms = 6.5), all showed co-seismic folding. Although the faulting parameters are appropriate for the associated earthquake magnitudes, the folding partly to completely obscures the seismogenic faults. To adequately assess the earthquake potential for each of these areas prior to these earthquakes, the co-seismic character of folding should have been assessed. This suggests the need to provide data for similar evaluations of the anticlinal folds of the Yakima Fold Belt.

Third, recent neotectonic studies of the Yakima Fold Belt, show that northwest trending strike-slip faults are believed by Anderson and Tolan (1986) to be contemporaneous with the anticlinal folds. This indicates the need for a broad-scale regional evaluation and a further investigation of the intertie between the northwesterly trending right-slip faults and the east-west trending anticlines.

APPROACH:

To quickly and at relatively low cost obtain preliminary evaluations of the neotectonic character of the Yakima Fold Belt, a remote sensing study is recommended. Earlier studies in this area include regional evaluations of this region for lineaments and major structures by Slemmons and Glass. They also acquired and evaluated by low-sun angle aerial photography parts of the

Columbia Plateau and Cascade Range. Fault mapping has been completed by the U. S. Corps of Engineers for this region. This study will build on this data base, but will expand the analysis using current knowledge, use and "multi" methods of study (Slemmons, 1981; Slemmons and others, 1981). This investigation will focus on specific faults and folds that will provide key information.

DISCUSSION:

The possibility of active (capable) tectonic features in the Yakima Fold Belt was first recognized by Campbell and Bentley in 1981 (Appendix A) when they recognized late Quaternary fault scarps along a crestal graben, a hinge fault, and a fan along the Mill Creek thrust fault at the northern edge of the Toppenish Ridge anticline. They measured fault scarps with heights of up to 4 m, presumably from one faulting event, and a zone of faulting of 32 km length. Slemmons (1982a and 1982b) in NUREG-0892, Supplement No. 1 and NUREG-0309, Supplement No. 3, showed that if the scarps were seismogenic and were formed during one earthquake, the Ms magnitude was about 7.4 with a deviation of about 0.3. This suggests a possible maximum earthquake for the Yakima Fold Belt Province, since this is along one of the longest and most prominent folds in the province.

The El Asnam earthquake in Algeria was associated with similar fault scarps, grabens, and anticlinal co-seismic folding along the main anticline (Philip and Meghraoui, 1983; Meghraoui and others, 1986). In Algeria, the surface faulting was also over a length of 32 km and the maximum offset was between 2 and 5 m, depending on the observations used. I have examined both the El Asnam faulting of 1984 and the Toppenish Ridge scarps and believe that Toppenish Ridge scarps may also be capable, seismogenic faults. Other observers who have examined both zones believe that this geologic structure may be seismogenic and should receive further study and evaluation. Another possibility is noted by Yeats (1986), who discusses this zone as a zone of flexural slip. He notes that other areas of flexural-slip faulting in southern California may be "low-shake" earthquake effects. The proposed study will provide initial data to assist in resolving this issue.

During the past two or three years co-seismic folding has been recognized to be an important tectonic effect of some large earthquakes (King and Stein, 1983). These relations appear to be especially well expressed in compressional tectonic regions like those of El Asnam, Tobas-E-Golshan and Coalinga. The lack of previous recognition of folds as seismogenic geologic structures, and the subdued surface expression of their active faults makes active fault recognition and evaluation a difficult task, especially for places like the Yakima Fold Belt, that needs more thorough remote sensing, field mapping and tectonic study.

The recent abstract of Anderson and Tolan (1986), strongly suggests that the active folds at the Toppenish Ridge latitude are interconnected with contemporaneous wrench (right-slip) faults of the Maupin, Laurel, Luna Butte, and Arlington faults. Their oral presentation at the Cordilleran Section of the Geological Society of America shows late Quaternary faulting and such major geomorphic expressions as excarpments, brachydomes, and interconnection with "conjugate" folds. These northwest-trending strike-slip faults are mentioned by Plescia and Golombek (1986) as possible "tear" faults. Their prevalence and apparent conjugate pattern to folds is summarized in a tectonic map of the region (Fig. 1) from the U. S. Army Engineer District (1981).

Some of the mapped faults of Toppenish Ridge (e.g. the Mill Creek fault) is about 1/2 mile north of the Satus Peak anticline, and in Qal and Touchet beds that appear on the map to be unaffected by the anticlinal growth or landslide processes. This may favor a tectonic origin.

The main goal of this unified remote sensing, including low-sun angle analysis, is needed to determine the continuity, length and interrelation of active appearing structures, including the apparent conjugate relation of faulting to folding.

A second goal of this study will be to determine:

(1) the locations of areas that are especially suitable to assessing the capability and style of deformation of faults and folds of the province.

(2) determine locations of possible sites that are suitable for exploratory trenching and detailed mapping of faults and folds.

STUDY METHOD:

The imagery will be analyzed by "multi" methods that are described in Slemmons, (1981) as shown in Appendix B. These methods should include methods for synoptic examination and low-sun angle evaluation, the most effective method for evaluation and detection of active (capable) faults. The imagery analysis will include:

(1) Radar imagery (already acquired by the Corps of Engineers), and new imagery to be obtained by the U. S. Geological Survey during the next year,

(2) Landsat imagery (older imagery is already acquired). New thematic mapper imagery will be added for this project for the Yakima Fold Belt at 1:250,000 scale in color and for selected selected MS wavelengths at 1:1,000,000 scale,

(3) Low-sun angle aerial photography will be acquired only

for those areas that were not included in the original photography collected by Washington Public Power Supply System,

(4) High altitude color IR and B&W aerial photography will be obtained for the region, and selected strips along faults and folds will be added for detailed study of selected structures.

The imagery analysis of major lineaments will be compiled at 1:250,000 scale on a map base. Emphasis will be on those faults and related folds that show geomorphic evidence for activity and have lengths or structural relations that are significant to the siting area.

The imagery analysis will receive a field and aerial reconnaissance evaluation to provide visual confirmations of the general findings. The final report will include recommendations for selection of specific field areas, or fault-fold geologic structures that need further evaluation.

The compilation can be initiated immediately and is not weather dependant. The field and aerial reconnaissance should be during the summer months, when clear weather is more frequent.

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